Please cancel Claim 13, without prejudice or disclaimer of that which is defined thereby.

REMARKS

Applicants have presented amendments to Claims 1 and 14-22 to more clearly define the invention. Claim 13 has been cancelled, without prejudice or disclaimer of that which is defined thereby. Replacement pages 41-51 are submitted herewith.

Applicants invite the Authorized Officer's attention to box V.1 in which Claims 1-49 are indicated to have been considered for novelty, inventive step and industrial applicability. However, Applicants believe that only Claims 1-30 have been presented to date during international preliminary examination. Accordingly, Applicants will provide comments with respect to Claims 1-30. Applicants thank the Authorized Officer for his indication that the claims possess industrial applicability.

Claims 19-22 stand objected to under PCT Rule 66.2(a)(v) as allegedly lacking clarity under PCT Article 6 for the reason stated in box VIII. Applicants have cancelled Claim 13 (on which these claims depend), changed the dependency of Claims 19-22 to Claim 1 and have introduced antecedent basis into Claim 1, as amended. Accordingly, Applicants believe that the objection should no longer be maintained.

One or more of Claims 1-30 have been objected as

the following documents: U.S. Patent No. 5,512,613; the English-language abstracts of Japanese Patent Document Nos. JP 11-17074, JP 8-12,741, JP 9-316,421, JP 58-42,290, JP 5-271,389, JP 2-18,412, JP 63-159,426, JP 62-295,029, and JP 6-136,092, and V.A. Sergeev et al., "Diglycidyl aromatic thio ethers and epoxy polymers derived from them", Vysokomol. Soedin., Ser. A, 26(1), 208-11 (1984), and an abstract of J.V. Crivello et al., "Structure and reactivity relationships in the photoinitiated cationic polymerization of oxetane monomers", J. Macromol. Sci., Pure Appl. Chem., A30(2-3), 189-206 (1993).[1]

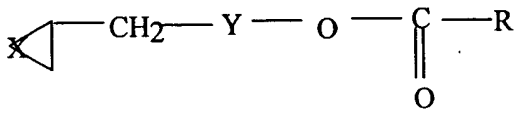
Applicants traverse these objections.

Applicants provide a review for the Authorized Officer of certain of the features and benefits of the invention embodied in the subject application.

The present invention is defined by a thermosetting resin composition, reaction products of which are controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition. The composition includes a curable resin component selected from the group consisting of curable resins having at least two heteroatom-containing carbocyclic structures pending from a core structure, with the core structure containing at least one ether, thioether or carbonate linkage that is capable of degrading upon exposure to elevated temperature conditions

1 No explanation of the objection has been raised with respect to any of the cited documents in box V.2 of the Written Opinion as far as inventive step is concerned.

and/or acidic conditions, epoxy resins having at least one alkylene oxide residue positioned adjacent at least one terminal epoxy group, and the combination of an epoxy resin and a coreactant diluent represented by the structure:



where X represents the heteroatoms, oxygen or sulfur; Y may or may not be present, and when present represents alkyl, alkenyl, and aryl; and R represents alkyl, alkenyl, and aryl. The composition also includes a curing agent component selected from amine compounds, modified amine compounds, amide compounds, modified amide compounds, imidazole compounds, modified imidazole compounds and derivatives and combinations thereof.

By using the thermosetting resin compositions of this invention, semiconductor devices, such as CSP/BGA/LGA assemblies, or semiconductor chips can be securely connected to a circuit board by short-time heat curing and with good productivity, with the resulting mounting structure demonstrating excellent heat shock properties (or thermal cycle properties).

Reaction products of these compositions are capable of being controllably reworked through the softening and loss of their adhesiveness, such as by exposure to temperature conditions in excess of those used to cure the composition. Thus, in the event of failure, the semiconductor device or semiconductor chip can be easily removed. This makes it

possible to reuse the circuit board, thereby achieve an improvement in the yield of the production process and reducing production cost.

The temperature used to effect such degradation of compositions within the scope of the present invention may be as great as 50°C lower than the temperatures required to degrade ordinary epoxy-based compositions used for this purpose, such as those based on bisphenol-A-type epoxy resins or bisphenol-F-type epoxy resins, which are ordinarily in the vicinity of about 300°C or more. This temperature differential is clearly advantageous in that it provides rework conditions that do not compromise the integrity of the semiconductor device while a failed semiconductor chip may be replaced.

Applicants now turn to the documents cited in the Written Opinion, and discuss each in the order in which it was cited.

The '613 patent speaks to a reworkable thermoset composition based on a diepoxide component in which the organic linking moiety connecting the two epoxy groups of the diepoxide includes an acid cleavable acyclic acetal group. With such acid cleavable acyclic acetal groups forming the bases of the reworkable composition, a cured thermoset need only be introduced to an acidic environment in order to achieve softening and a loss of much of its adhesiveness.

The '613 patent appears to be the only document cited in the Written Opinion against Claims 1-30 that mentions the concept of reworkability (or recyclability). However, the

compositions of the '613 patent specify that the degradable linkage of the epoxy resin is an acid-sensitive acetal linkage. Applicants' claims do not indicate use of an acetal group as a cleavable linkage in the curable resin, and provides for reworkability through localized heating.

The English-language abstract of the JP '074 document speaks to compositions based on oxetane compounds, such as xylene bis-oxetane, that are cured by a sulfonium salt cure catalyst.

While oxetane compounds are contemplated within the scope of the present invention, Applicants' claims require specific curing agents other than sulfonium salts. In addition, this abstract does not appear to teach or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition.

The English-language abstract of the JP '741 document speaks to an epoxy resin composition containing 100 parts epoxy resin, 50-150 parts of 1,4-cyclohexane dimethanol diglycidyl ether, an acid anhydride curing agent and a curing promoter. This composition is described as having low viscosity and being useful as an impregnation sealant for electronic parts, such as solenoid coils.

The English-language abstract of the JP '421 document speaks to a composition containing MPG and an aromatic sulfonium salt curing catalyst. The composition is

touted for its high refractive index.

While MPG is contemplated within the scope of the present invention, Applicants' claims require specific curing agents other than sulfonium salts. In addition, this abstract does not appear to teach or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition.

The English-language abstract of the Sergeev speaks to the curing of diglycidyl thio ethers with sulfur-containing diamines to yield a product with higher mechanical strength and glass transition temperature, compared with a cured bisphenol-A epoxy resin.

Sergeev, however, does not appear to teach, disclose or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition.

The English-language abstract of the JP '290 document speaks to the manufacture of thin, mechanically strong circuit boards with heat-resistant polymer-coated fluoropolymer films that have been heat treated and laminated with copper foil. The laminating material appears to contain an epoxy resin, a BPO-20E epoxy ether and a heterocyclic polyamine. The circuit boards are reported to demonstrate excellent heat and moisture resistance.

While BPO-20E is contemplated within the scope of

the present invention, this abstract does not appear to teach or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition. In addition, mechanically strong circuit boards that have been laminated using an epoxy-based composition so as to demonstrate excellent heat and moisture resistance contradicts the ability of reaction products of the present invention to controllably degrade under appropriate conditions. Accordingly, the JP '290 document teaches away from Applicants' invention.

The English-language abstract of the JP '389 document speaks to epoxy resin compositions containing epoxy resins, modified silicone resins, silicone catalysts, dehydration agents, and di- and/or tri-ketimines. The ketimine used to cure the epoxy resin requires the presence of water to react.

The JP '389 document does not teach, disclose or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition.

The English-language abstract of the JP '412 document speaks to an epoxy composition containing 100 parts epoxy resin, 30-60 parts bisphenol A epoxy resin having alkylene ether bonds, 5-30 parts aliphatic or aromatic glycidyl ethers and 80-150 parts polyamideamines. This

composition is reported to be a casting material having good workability, reaction products of which are flexible and demonstrate a small hardness change over time.

This abstract does not appear to teach or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition.

The English-language abstract of the JP '426 document speaks to flexible and heat-resistant compositions based on epoxy resins, epoxy resin-alkylene oxide adducts, aliphatic glycidyl ethers, and hardening accelerators.

This abstract does not appear to teach or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition. More specifically, a heat-resistant composition is one whose cured product shows resistance to heat; a reworkable composition is one whose cured product shows the ability to controllably degrade. These physical properties are the exact opposite of one another. Accordingly, the JP '426 document teaches away from Applicants' invention.

The English-language abstract of the JP '029 document speaks to a liquid crystal device sealed with an epoxy resin composition. The epoxy resin composition contains a novolac epoxy resin, a novolac phenolic resin hardener, a

flexible epoxy resin, alumina and/or silica fillers, and an imidazole-curing accelerator.

This abstract does not appear to teach or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition.

The English-language abstract of the JP '092 document speaks to a two part epoxy composition containing as a first part a mixture of 1,4-cyclohexanedimethanol diglycidyl ether and hydrogenated bisphenol A diglycidyl ether, and as a second part an aliphatic polyamine curing agent and preferably an acid anhydride. This composition is reported to be useful as a light emitting diode sealant.

Unlike Applicants' compositions, the compositions of the JP '092 documents appear to be two part systems, indicating that they do not possess the shelf stability to be commercially acceptable as one part systems. In addition, this abstract does not appear to teach or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition.

The abstract of Crivello speaks to CBO cured with a phenyliodonium or phenylsulfonium fluoroantimonate.

While CBG is contemplated within the scope of the present invention, Applicants' claims require specific curing

agents other than phenyliodonium or phenylsulfonium fluoroantimonates. In addition, this abstract does not appear to teach or suggest Applicants' requirement that the compositions of the present invention be controllably degradable upon exposure to temperature conditions less than those used to cure the thermosetting resin composition.

Thus, it is seen that none of the documents individually (save for the '613 patent) speak to the highly desirable ability of reaction products of the respective compositions to controllably degrade upon exposure to temperature conditions less than those used to cure the thermosetting resin composition. While a few of the documents appear to mention certain curable resins that are suitable for use herein, none of those documents seem to employ the type of curing agent required for use herein and as noted above are not directed to reworkable thermosetting resin compositions.

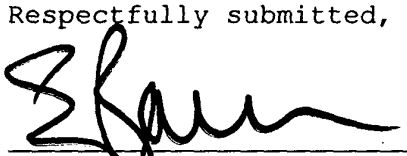
In addition, the '613 patent, which has recognized the desirability of providing a reworkable composition, has done so using different chemistry than Applicants have set forth in the subject application, chemistry which is degradable by exposure to dilute acid. Applicants are of the opinion that such a rework process is a less desirable one from a commercial setting to the extent that liquids need to be dispensed into and controlled within a localized area where the cured product should be processed.

In view of the above, Applicants believe the claims as amended are in a form that meet all requirements of PCT

Article 33, and therefore all objections should be removed. Applicants thus respectfully request the issuance of a favorable international preliminary examination report.

Should the authorized officer have any questions concerning the amendments set forth above, the officer is invited to contact the undersigned attorney by telephone at (860) 571-5001, by facsimile at (860) 571-5028, or by email at steve.bauman@loctite.com.

Respectfully submitted,



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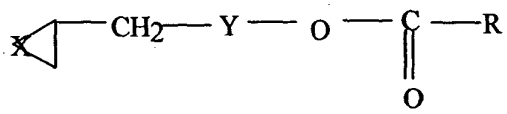
1. A thermosetting resin composition, reaction products of which are controllably degradable upon exposure to temperature conditions less than those used to cure said composition, said composition comprising:

(a) a curable resin component selected from the group consisting of curable resins having at least two heteroatom-containing carbocyclic structures pending from a core structure, with the core structure containing at least one ether, thioether or carbonate linkage that is capable of degrading upon exposure to elevated temperature conditions and/or acidic conditions, epoxy resins, at least a portion of which having at least one alkylene oxide residue positioned adjacent at least one terminal epoxy group, and the combination of an epoxy resin and a coreactant diluent represented by the structure:



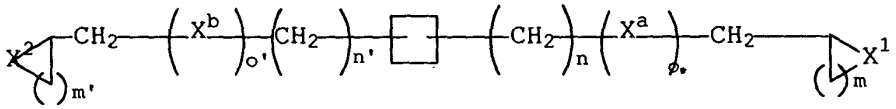
wherein X represents the heteroatoms, oxygen or sulfur; Y may or may not be present, and when present represents alkyl, alkenyl, and aryl; and R represents alkyl, alkenyl, and aryl; and

(b) a curing agent component selected from the group consisting of amine compounds, modified amine compounds, amide compounds, modified amide compounds, imidazole compounds, modified imidazole compounds and derivatives and combinations thereof.

2. The composition of Claim 1, further comprising an anhydride component.

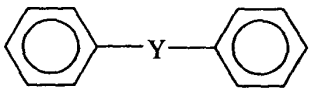
3. The composition of Claim 1, further comprising an inorganic filler component.

4. The composition of Claim 1, wherein the curable resin component is represented by the following structure:



wherein the box represents one or more aromatic ring(s) or ring system(s), with or without interruption or substitution by one or more heteroatoms; X^1, X^2 X^a, and X^b may be the same or different and represent oxygen and sulfur; m and m^1 represent integers within the range of 1 to 3; n and n^1 represent integers within the range of 0 to 8; and o and o^1 represent integers within the range of 1 to 3.

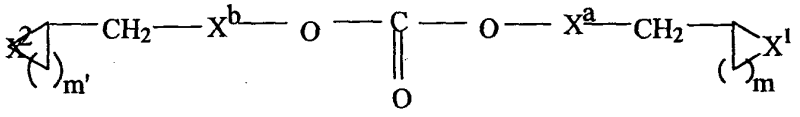
5. The composition of Claim 4, wherein the box is represented by



wherein Y may or may not be present, and where present a member selected from the group consisting of carbon, oxygen, sulfur, and phenylene.

6. The composition of Claim 4, wherein the box represents a structural linkage selected from the group consisting of individual aromatic rings, oligomeric systems and aromatic ring systems having multiple aromatic units joined in fused ring systems, joined in bi-aryl ring systems, bis-aryl ring systems, or cycloalaphatic-aromatic hybrid ring systems.

7. The composition of Claim 1, wherein the curable resin component is represented by the following structure:

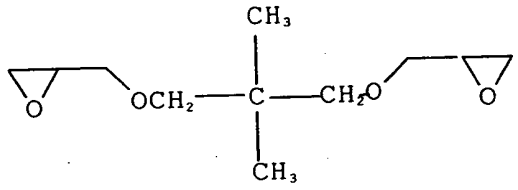


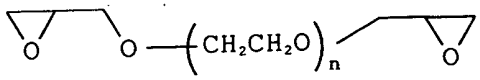
wherein X^1 and X^2 may be the same or different and represent oxygen and sulfur; X^a and X^b may be the same or different, may or may not be present, and represent alkyl, alkenyl, and aryl of one to about twenty carbon atoms, or one or more aromatic ring(s) or ring system(s), with or without interruption or substitution by one or more heteroatoms; and m and m^1 represent integers within the range of 1 to 3.

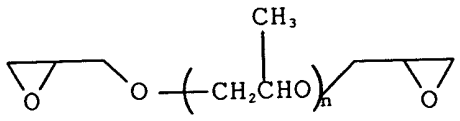
8. The composition of Claim 1, wherein the curable resin component is a member selected from the group consisting of MPG [bis[4-(2,3-epoxy-propylthio)phenyl]-sulfide], XBO [xylene bisoxetane], CBO (carbonate bisoxetane), and combinations thereof.

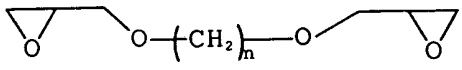
9. The composition of Claim 1, wherein the epoxy resin component includes mono- or multi-functional aliphatic epoxies, epoxies with a cycloaliphatic ring structure or system, or epoxies with an aromatic ring structure or system, and combinations thereof.

10. The composition of Claim 1, wherein the epoxy resin component includes

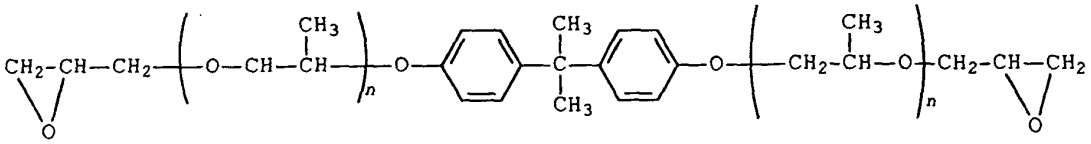


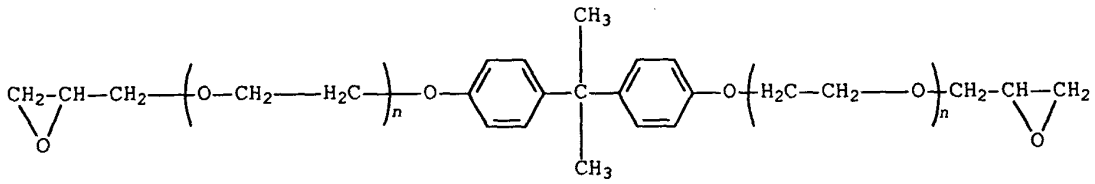




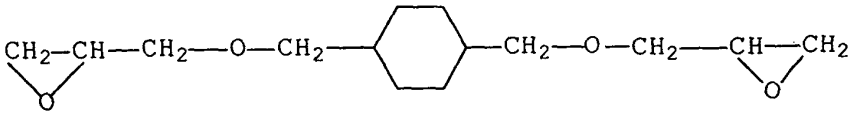


wherein n is an integer from 1 to about 18,



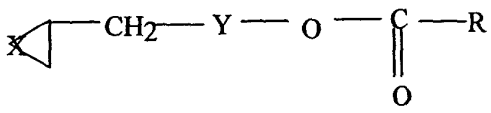


wherein n is as defined above,



and combinations thereof.

11. The composition of Claim 1, wherein the coreactant diluent is represented by the structure:



wherein X represents the heteroatoms, oxygen or sulfur; Y may or may not be present, and when present represents a linkage selected from the group consisting of linear, branched, cyclo or bicyclo alkyl or alkenyl of from one or two, respectively, to about twenty carbon atoms, and

aryl of one or more aromatic ring(s) or ring system(s) of from about six to about twenty carbon atoms.

12. The composition of Claim 1, wherein the coreactant diluent is glycidyl neodecanoate.

13. (Canceled) The composition of Claim 1, wherein the amine compounds are selected from the group consisting of aliphatic polyamines, aromatic polyamines, alicyclic polyamines and combinations thereof.

14. The composition of Claim 1, wherein the amine compounds are selected from the group consisting of aliphatic polyamines, aromatic polyamines, alicyclic polyamines and combinations thereof.

15. The composition of Claim 1, wherein the amine compounds are selected from the group consisting of diethylenetriamine, triethylenetetramine, diethylaminopropylamine, xylenediamine, diaminodiphenylamine, isophoronediamine, menthenediamine and combinations thereof.

16. The composition of Claim 1, wherein the amide compounds include cyano-functionalized amides.

17. The composition of Claim 1, wherein the imidazole compounds are selected from imidazole, isoimidazole, alkyl-substituted imidazoles, and combinations thereof.

18. The composition of Claim 1, wherein the imidazole compounds are selected from 2-methyl imidazole, 2-ethyl-4-methylimidazole, 2,4-dimethylimidazole, butylimidazole, 2-heptadecenyl-4-methylimidazole, 2-methylimidazole, 2-undecenylimidazole, 1-vinyl-2-methylimidazole, 2-n-heptadecylimidazole, 2-undecylimidazole, 2-heptadecylimidazole, 2-ethyl 4-methylimidazole, 1-benzyl-2-methylimidazole, 1-propyl-2-methylimidazole, 1-cyanoethyl-2-methylimidazole, 1-cyanoethyl-2-ethyl-4-methylimidazole, 1-cyanoethyl-2-undecylimidazole, 1-cyanoethyl-2-phenylimidazole, 1-guanaminoethyl-2-methylimidazole and addition products of an imidazole and trimellitic acid, 2-n-heptadecyl-4-methylimidazole, aryl-substituted imidazoles, phenylimidazole, benzylimidazole, 2-methyl-4,5-diphenylimidazole, 2,3,5-triphenylimidazole, 2-styrylimidazole, 1-(dodecyl benzyl)-2-methylimidazole, 2-(2-hydroxyl-4-t-butylphenyl)-4,5-diphenylimidazole, 2-(2-methoxyphenyl)-4,5-diphenylimidazole, 2-(3-hydroxyphenyl)-4,5-diphenylimidazole, 2-(p-dimethylaminophenyl)-4,5-diphenylimidazole, 2-(2-hydroxyphenyl)-4,5-

diphenylimidazole, di(4,5-diphenyl-2-imidazole)-benzene-1,4, 2-naphthyl-4,5-diphenylimidazole, 1-benzyl=2-methylimidazole, 2-p-methoxystyrylimidazole, and combinations thereof.

19. The composition of Claim 1, wherein the modified amine compounds include epoxy amine additives formed by the addition of an amine compound to an epoxy compound.

20. The composition of Claim 1, wherein the modified amine compounds include "ANCAMINE" 2337S.

21. The composition of Claim 1, wherein the modified amine compounds are novolac-type resin modified through reaction with aliphatic amines.

22. The composition of Claim 1, wherein the modified imidazole compounds include imidazole adducts formed by the addition of an imidazole compound to an epoxy compound.

23. The composition of Claim 2, wherein the anhydride component is a member selected from the group consisting of hexahydrophthalic anhydride, methyl hexahydrophthalic anhydride, 5-(2,5-dioxotetrahydrol)-3-

methyl-3-cyclohexene-1,2-dicarboxylic anhydride, and combinations thereof.

24. The composition of Claim 3, wherein the inorganic filler component is a member selected from the group consisting of silica, aluminum oxide, silicon nitride, aluminum nitride, silica-coated aluminum nitride, boron nitride and combinations thereof.

25. A thermosetting resin composition capable of sealing underfilling between a semiconductor device including a semiconductor chip mounted on a carrier substrate and a circuit board to which said semiconductor device is electrically connected, or a semiconductor chip and a circuit board to which said semiconductor chip is electrically connected, reaction products of which are capable of softening and losing adhesivensss comprising:

a curable resin component as set forth in Claim 1 in an amount in the range of from about 20% by weight to about 60% by weight, a curing agent component in an amount within the range of from about 1 to about 10% by weight, and optionally an anhydride component in an amount within the range of from about 10 to about 60% by weight, and optionally an inorganic filler component in an amount up to about 60% by weight.

26. Reaction products of the compositions in accordance with any one of Claims 1-25.

27. An electronic device comprising a semiconductor device and a circuit board to which said semiconductor device is electrically connected or a semiconductor chip and a circuit board to which said semiconductor chip is electrically connected, assembled using a thermosetting resin composition according to any one of Claims 1-25 as an underfill sealant between the semiconductor device and the circuit board or the semiconductor chip and the circuit board, respectively, wherein reaction products of the composition are capable of softening and losing their adhesiveness under exposure to temperature conditions in excess of those used to cure the composition.

28. A method of sealing underfilling between a semiconductor device including a semiconductor chip mounted on a carrier substrate and a circuit board to which said semiconductor device is electrically connected or a semiconductor chip and a circuit board to which said semiconductor chip is electrically connected, the steps of which comprise:

(a) dispensing into the underfilling between the semiconductor device and the circuit board or the

semiconductor chip and the circuit board a composition in accordance with any one of Claims 1-25; and

(b) exposing the composition as so dispensed to conditions appropriate to cause the composition to form a reaction product.

29. A method of reworking a reaction product of a composition in accordance with any one of Claims 1-25, a step of which comprises:

(a) exposing the reaction product to conditions appropriate to cause the reaction product to soften and lose adhesiveness.

30. The method according to Claim 29, further comprising the steps of:

(b) removing the semiconductor chip or semiconductor device from the circuit board; and

(c) optionally, cleaning the surface of the circuit board to remove any cured reaction product that remains.